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Biodegradation of confectionery effluents using microbial assisted activated sludge

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Abstract

The common characteristic features of Confectionery industry wastewater are high concentration of soluble pollutants, high COD, BOD, TSS and acidic pH. The effluent treatment process in Confectionery industry, mainly depends on anaerobic digestion for maximum reduction of COD and BOD levels. The present investigation focuses on studying the biodegradation capacity of primary activated sludge and raw anaerobic sludge at different COD concentrations of effluent with the COD reduction efficiency. The anaerobic digestion is carried out in a laboratory scale batch reactor at varying COD concentrations for both the sludge types subsequently. The maximum COD reduction rate was obtained from the total effluent of COD concentration of 1512 mg/l, which on treatment with primary activated sludge and raw anaerobic sludge reduced to 586.7mg/l (61.2%) and 568.5 mg/l (62.4%) respectively. As the COD concentration in the effluent increased, the biodegradation rate started to slow down. Of the two sludges used for the anaerobic digestion of the effluent, it was observed that the raw anaerobic sludge gave a higher COD reduction than the primary activated sludge. To conclude, raw sludge used in anaerobic batch reactor set up gave the best COD reduction in this laboratory scale investigation.

Key words : BOD, COD, Biodegradation, Effluent.

INTRODUCTION

After industrialization and population boom, the amount of waste/effluent dumped into the water bodies has reached beyond the degrading capacity of the microbes in water bodies. The untreated effluents from industries alter the quality parameters such as BOD, COD, dissolved oxygen, etc. (Sinha et al., 2014). Some of the components of the effluents are difficult to degrade naturally. Due to this, water pollution has rapidly increased, causing much concern all over the world (Dhall et al., 2012). Thus a treatment plant is mandatory in every industry to treat the effluents. Prior to designing any treatment plant/process, the characterization of waste water is required to study its characteristics. The physical characteristics involve total solid content, colour, odor and temperature. The chemical characteristics of wastewater include pH, alkalinity, organic and inorganic content and heavy metal content. BOD, COD and TOC tests are commonly carried out to estimate the organic content of the effluents. Gas chromatography and mass spectroscopy can be used to trace the organic content Biological/ Biochemical Oxygen demand (BOD) is a measure of oxygen required by aerobic microbes for oxidation of organic matter. Chemical Oxygen demand (COD) indicates the amount of oxygen is needed for the oxidation of all organic maters in water. The major advantage of COD is that it is time consuming and it can be used to test toxic wastes. Confectionery industry is one of the main sectors of all food industries. Its effluent is characterized by high BOD and COD values due to the presence of high organic matter. The organic content is comprised of sludge, milk proteins, heavy organic matter, fats, oil and grease, fatty acids, nitrogenous compounds, emulsifiers, lactose, inorganic salts, detergents (cleaning), dissolved sugars and other additives. Confectionery effluent has high fat and protein content in their effluents along with carbohydrates. Due to organic acids produced from sugars aerobically and existing fatty acids, the pH is slightly acidic (pH 5-6). TSS is also high due to both organic and inorganic content used in the confectionery industry. Fats, oil and grease contents are high in confectionery and dairy industries (El-Gohary et al., 1999; Orhon et al., 1995; Diwani et al., 2000; Ozturk and Altinbas., 2008). Most of the effluent treatment plants in confectionery industries employ aerobic and anaerobic digestion along with filtration to treat the high organic effluent content (Ersahin et al., 2011). A common Effluent Treatment Process (ETP) can be divided into three levels: At the primary level, separation of suspended particles and floating particles from the effluent is carried out; at the secondary level, (biological treatment) the BOD levels are reduced by the action of microbes on organic matter; and at the tertiary level, (advanced treatment) 99% of pollutants are removed from wastewater, making it almost equivalent to drinking water.

Food effluent wastewater are generally treated using activated sludge process, aerated lagoons, trickling filters, Sequencing Batch Reactor(SBR), Anaerobic Sludge Blanket(UASB) reactor and aerobic filters (Porwal et al., 2014). Along with and sometimes without aerobic treatment, many industries prefer anaerobic treatment to treat wastewater. The general Effluent Treatment Plant in industries always has anaerobic treatment tanks, mostly aerobic following the anaerobic treatment. In the absence of oxygen, organic matter gets degraded down to methane. In UASB reactor, the waste water is flown upward lower than the settling velocity

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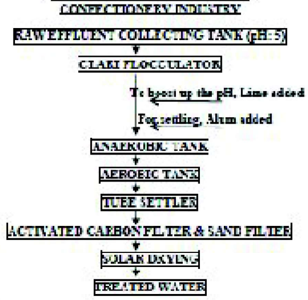


Fig 1.1 BASIC ETP PROCESS IN A CONFECTIONERY INDUSTRY

of granules. Sludge bed is provided such that it carries out anaerobic digestion of the effluent. However it is observed that the COD levels didnot fall below 80%. A better alternative used is a two stage process involving aerobic and anaerobic reactors thus obtaining methane as a byproduct. For high level COD, a UASB reactor and a secondary anaerobic reactor treatment of effluent give a much better fall in COD (Ersahin et al., 2011). A simple aerobic degradation involves inoculation of aerobic microbes into the effluent, formation of sludge that acts on the effluent and finally filtration is carried out to get the treated effluent out (Porwal et al., 2014). With this background information, the present article deals with degradation of confectionery effluents using microbial assisted activated sludge.

MATERIALS AND METHODS

Collection of sample

The Effluent sample was collected from Confectionery industry's Effluent Treatment Plant (ETP), Chennai.

Collection of sludge

The raw and primary sludge was collected from Wastewater Treatment Plant, Koyambedu.

Characterization of Confectionery Effluents

TSS

Total Suspended Solids (TSS) was determined gravimetrically by passing the diluted effluent sample through weighed filter and then drying the filter at 103-105ÚC. The non filterable residue was calculated from increase in mass of the filter.

Oil and grease Content

Oil and grease content was de terminedby partition gravimetric method using trichlorotrifluoroethane as a solvent. To one liter sample, 30ml solvent was added and by using separating funnel the layers were allowed to separate and then collected. This process was repeated for raffinate to get total oil and grease content.

Protein content

Total protein content in the effluent was estimated by the Kjeldahl method. Based on TKN (Total Kjeldahl Nitrogen), the total protein content was estimated for the effluent by applying conversion factor.

COD Analysis

COD determination was carried out using the dichromate method with the addition of 5 ml of 0.1 N potassium dichromate ($K_2Cr_2O_7$) in 50 ml sample, blank and sludge respectively. The mixture was left in water bath at 100Ú C for 1 hour and was cooled to room temperature. 5 ml of KI and 10 ml of 2M H_2SO_4 was added to each of the flasks.The content of each flask was titrated against 0.1 M sodium thiosulphate until the appearance of pale yellow colour. 1 ml of starch solution was then added to each flask till the solution turns blue. Again it was titrated against sodium thiosulphate until the disappearance of blue colour. The COD was calculated using the following formula

$$COD\ (mg/lit) = \frac{8 \times C \times (B-A)}{S}$$

Where,

C- Concentration of titrant (g/l)

S- Volume of sample taken.

B-Volume of titrant used for blank

A-Volume of titrant used for the sample taken.

COD readings were recorded for pure effluent and sludge.

BOD Analysis

BOD was estimated by preparing the required volume of dilution water with the addition of nutrients, namely phosphate buffer, magnesium sulfate, calcium chloride and ferric chloride. The diluted sample was transferred to BOD bottles. After determining initial DO (Dissolved Oxygen), final DO was estimated for the bottles which were kept for incubation period of five days. The bottles kept for DO determination and blank were fixed by adding 2 ml manganese sulfate ($MnSO_4$), 2 ml of alkali iodide azide.

Experimental Procedure

Optimization of sludge for higher COD removal efficiency

1.5 liters of 5% effluent was prepared using distilled water as diluent. The COD of untreated 5% effluent was determined as described previously. In reactor filled with 250ml activated sludge, 1 litre of the prepared 5% effluent was added and allowed to incubate for 2 days where agitation and O_2 were provided. After incubation, the COD of treated effluents was calculated. The percentage of COD removal was also calculated. Using the same process, the COD and COD removal percentage for untreated and treated10%, 15%, 20%, 25%, 30%, 35%, 40%, 45% and 50% effluent was calculated and recorded. The process was repeated for anaerobic sludge treatment, providing anaerobic conditions for growth of methanogens. The COD reduction efficiencies of aerobic and anaerobic sludge were compared.

RESULTS AND DISCUSSION

Characterization of the confectionery effluent

The raw effluent was obtained from the effluent collecting tank for characterization. The effluent was yellowish in colour and had an unpleasant odor. The initial pH of confectionery effluent was observed to be acidic (pH-5).

The five basic parameters of the confectionery effluent were studied: BOD, COD, Oil and grease, TSS and protein content by the protocols published for wastewater analysis in Bureau of Indian Standards. The BOD and COD were high and they were 2180.0 mg/l and 7667.0 mg/l respectively. The TSS was 3080.0 mg/l while the oil and grease level was 112mg/l.(Table 1) Both these high values were due to the presence of insoluble fats in the effluent respectively. The Total Nitrogen content was determinrd by Kjeldahl process and a conversion factor of 6.38 was applied to calculate the total protein content of the effluent. From the physiochemical analysis of raw confectionery effluent it was concluded that, the effluent has high organic acid content, relatively smaller protein content, high fat content, high suspended solids content and acidic pH. (Fig.1)

Table 1: Characterization of the confectionery effluent

S.NO	PARAMETERS	RESULTS
1.	INITIAL pH	5
2.	TSS	3080.0 mg/l
3.	COD	7667.0 mg/l
4.	BOD	2180.0 mg/l
5.	TKN (CONVERSION OF NITROGEN TO PROTEIN %)	0.244 %
6.	OIL AND GREASE	112 mg/l

Study of biodegradation of effluent by primary activated sludge and raw anaerobic sludge using a batch reactor

A laboratory scale batch reactor was utilized to carry out studies on anaerobic treatment by primary activated sludge and raw sludge on confectionery effluent at varying COD concentrations. Two outlet openings at 250 ml and 500 ml level of the vessel were provided to collect the samples. The reactor was completely sealed for the batch scale anaerobic digestion process, which was carried out by primary activated sludge and raw anaerobic sludge subsequently. The COD concentration level of the effluent was slowly increased in the reactor, in both cases, to get maximum COD reduction capacity. Fig.2 The graph showed the increase in COD removal percentage with an increase in concentration levels for both primary activated and raw anaerobic sludge respectively. The COD removal rate showed a maximum increase at 30% effluent concentration; initial COD level of 1512 mg/l reduced to 586.7 mg/l for activated sludge and 568.5 mg/l for anaerobic sludge, giving 61.2% and 62.4% COD reduction respectively Table 2. As the concentration increased, the COD removal rate increased at a slower rate due to higher organic load of effluent. On comparing the two methods, aerobic and anaerobic digestion, it was observed that the activated sludge showed COD reduction of 72.4%, while the anaerobic sludge showed COD reduction of 88.2% at 50% effluent concentration, and it is concluded that raw sludge is more efficient in COD removal than primary activated sludge in anaerobic digestion. It is to be noted that anaerobic sludge process has less energy demand as compared to the aerobic process, making it ideal for application in smaller industries. Optimization of sludge for higher COD removal efficiency (Fig. 3)

Table 2. Primary Activated sludge
Time interval for degradation of the effluent: 2 Days

Dilution of the Effluent (%)	COD of untreated effluent (mg/l)	COD of treated effluent by Primary Activated Sludge (mg/l)	COD reductionin percentage
5	616	536	13 %
10	728	536	26.37 %
15	840	576	31.43 %
20	1192	696	41.61 %
25	1392	712	48.85 %
30	1512	586.7	61.2 %
35	1672	611.9	63.40 %
40	1896	633.4	66.59 %
45	2216	682.52	69.20 %
50	2536	699.9	72.40 %

CONCLUSION

The results obtained from the characterization of the confectionery effluent concluded that the effluent has acidic pH, high BOD and COD; implying high organic content and high TSS. From the laboratory scale batch reactor, the study of anaerobic digestion by sludge at varying COD concentration levels of the effluent, it was observed that, the maximum COD reduction rate was obtained from the effluent that had an initial COD level of 1512 mg/l, which on treatment with primary activated sludge and raw sludge reduced to 586. 7mg/l (61.2%) and 568.5 mg/l (62.4%) respectively Table 3. When effluent with initial COD of 2536 mg/l, was treated with primary activated sludge and raw sludge, COD reduction was found to be 72.4% and 88.2% respectively. Thus, raw sludge was better for anaerobic treatment of effluent than primary activated sludge. It was concluded that the raw sludge used in anaerobic batch reactor set up

Figure 1. COD Reduction by Primary Activated Sludge

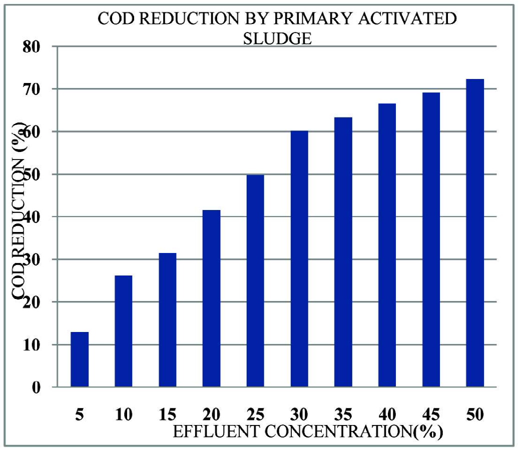


Table 3. Raw Anaerobic Sludge

Dilution of the Effluent (%)	COD of untreated effluent (mg/l)	COD of treated effluent by Raw Anaerobic sludge (mg/l)	COD reduction percentage
5	616	552.8	10.26%
10	728	552.86	24.06%
15	840	555.2	33.90%
20	1192	673.4	43.51%
25	1392	693.2	50.20%
30	1512	568.51	62.40%
35	1672	546.74	67.30%
40	1896	500.54	73.60%
45	2216	412.18	81.40%
50	2536	299.25	88.20%

Figure 2. COD Reduction by anaerobic sludge

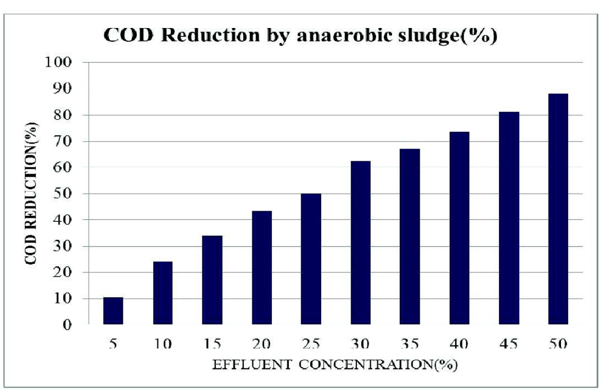
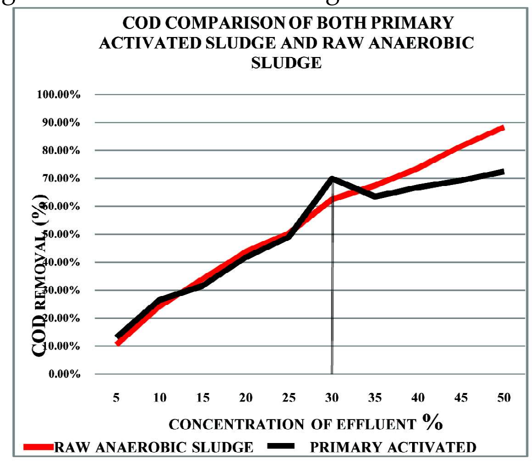


Figure 3. Comparison of COD reduction in Activated sludge and Raw Anaerobic sludge



gave the best COD reduction in this laboratory scale investigation and further optimization of conditions was required to enhance the biodegradation capacity of the culture.

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